

THE PREDATION OF GOSHAWKS UPON RUFFED GROUSE ON THE CLOQUET FOREST RESEARCH CENTER, MINNESOTA¹

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THE Goshawk (*Accipiter gentilis*), normally nesting in remote boreal or montane forest regions, is seldom considered a significant problem in small game management programs. Darrow (*in* Bump, et al., 1947) considered the Goshawk to be unimportant as a predator upon Ruffed Grouse (*Bonasa umbellus*) in New York state, stating (p. 327), "During the winters in which goshawks appeared grouse kills attributable to them were found but the net effect on overwinter loss was not appreciable." Roberts (1936) and Grange (1948) similarly considered the Goshawk unimportant as a threat to small game populations because of its seasonal and/or sporadic appearance in areas where this species' depredations come into conflict with man's interests.

However, Edminster (1947:197) lists the Goshawk as a grouse predator of "primary importance" in the northeast, and notes (p. 206) "The goshawk is the one species of predator for which ruffed grouse furnishes a really big proportion of the food." He also comments (*loc. cit.*), "It may be fortunate for grouse that the goshawk is not more generally plentiful." Few reports dealing with the Ruffed Grouse and the factors causing decimation of its populations fail to mention the Goshawk.

Fisher (1893), and most subsequent authors discussing the Goshawk (including McAtee, 1935; Roberts, *op. cit.*; Bent, 1937; and Mendall, 1944) agree that the largest of the so-called "bird hawks" is bold and rapacious. Fisher (*op. cit.*:45) comments, "In some parts of the country the Goshawk hunts the ruffed grouse so persistently that it is known by the name of 'Partridge Hawk', and this bird probably has no worse enemy except man."

Nearly every report on the food habits of Goshawks lists a high incidence of small game species, particularly Ruffed Grouse, in the diet. Latham (1950) lists Ruffed Grouse as being one of the most frequent prey of Goshawks in the northeastern United States. In a listing (p. 8-9) of the contents of 1,105 Goshawk stomachs, Ruffed Grouse remains occurred in 255 instances (23 per cent of the stomachs). Only domestic poultry (with 301 occurrences) exceeded Ruffed Grouse in the sample. On the other hand Meng (1959) found remains of only five Ruffed Grouse among 185 prey items brought to 14 Goshawk nests studied in New York and Pennsylvania.

During the course of five years (1956-1961) of Ruffed Grouse investiga-

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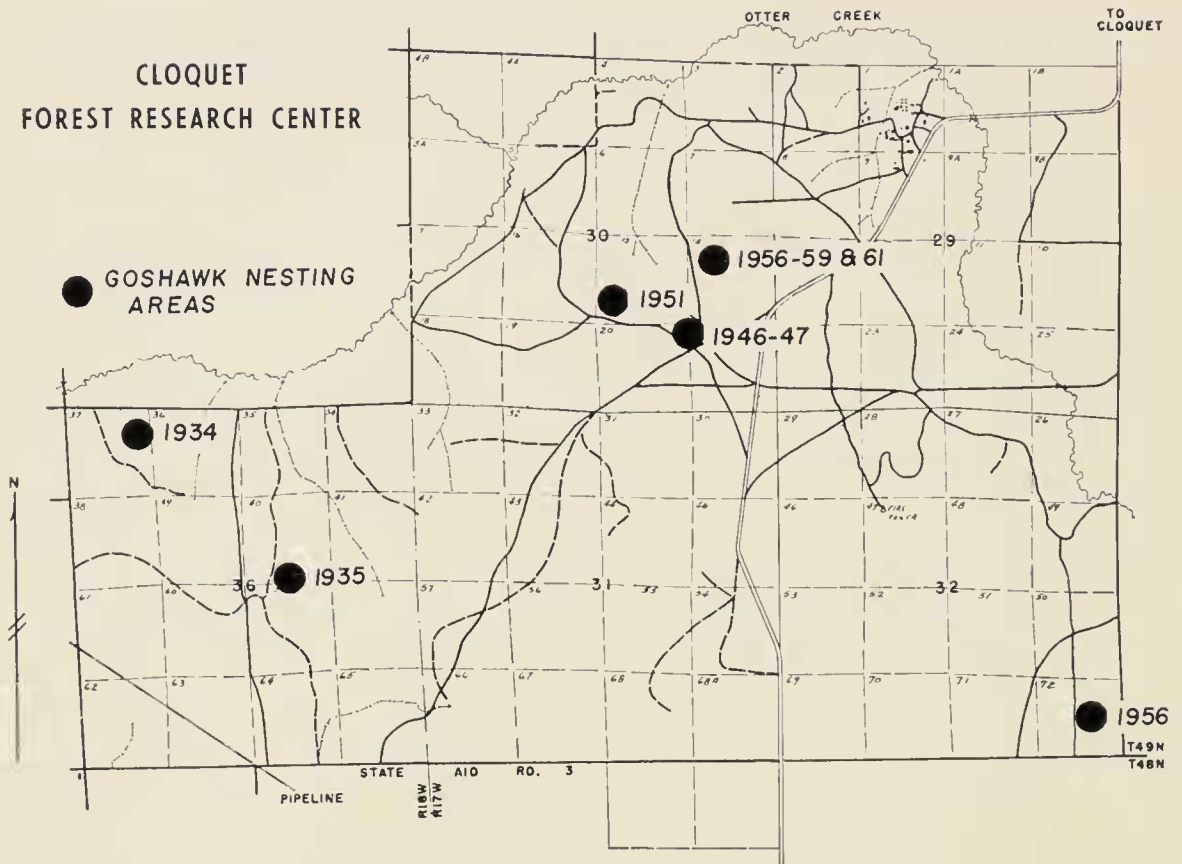


FIG. 1. Location and years of use of Goshawk nesting areas on the Cloquet Forest Research Center, Minnesota.

tions on the Cloquet Forest Research Center, 25 miles west of Duluth, Minnesota, we have had an opportunity to observe the depredations of Goshawks upon Ruffed Grouse, and to partially evaluate the effect of this predation upon over-all grouse populations (cf. Eng, 1959). This grouse population is essentially unhunted since the Research Forest is closed to small game hunting. The hunting harvest of grouse banded on this area is largely restricted to birds that have dispersed from the Forest.

HISTORICAL RECORD

Although Roberts (op. cit.:302-304) notes a scarcity of Goshawk nesting records for northern Minnesota, there is a 27-year history of Goshawk nesting on the Cloquet Research Forest (see Burcalow and Marshall, 1958, for a description of this area).

Morse (1934) reported the presence of a pair of nesting Goshawks on the western part of the Research Forest in 1934 (Fig. 1). In 1959, William L. Webb remarked (verbal communication) that Ralph T. King, formerly engaged in Ruffed Grouse research on this area, believed the 1934 record to be the first report of nesting Goshawks on the Research Forest. But ample evidence of Goshawk predation on Ruffed Grouse on this Forest is contained

in King's unpublished notes as early as November 1931. Of 85 predator kills of grouse noted by King from 1931 to 1934, at least 10 appear to be characteristic of Goshawk predation.

From about 1936 to 1956, wildlife investigations were of sporadic nature on the Research Forest, and Goshawk records are scanty. Raymond A. Jensen recalls the presence of a Goshawk nest in the central part of the Forest in 1946 or 1947 and in 1951 (Fig. 1).

The current history of Goshawks on this area begins in 1956, with a pair of Goshawks nesting in the southeastern corner of the Forest (Fig. 1). Their three fledglings left the nest shortly before 26 July. Since this pair was present only one season, and apparently took few, if any, Ruffed Grouse during their nesting period, the remainder of the discussion will deal largely with the hawks nesting in the north-central part of the Forest.

From 1956 to 1961 a pair of Goshawks had a focal point of activity and their nests in an area of about five acres in the north-central part of the Forest (Fig. 1). These birds were not banded so we do not know that the same pair occupied this area throughout this period. The 1956 nest was about 25 feet up in a jack pine (*Pinus Banksiana*), and fledged at least three young. In 1957 the nest was 24 feet above the ground in a 50-foot 8" dbh jack pine, and three young left the nest on about 20 July. The 1958 nest was 34 feet off the ground, in a 55-foot 8" dbh jack pine, and fledged an unknown number of young. In 1959, the nest was 32 feet up in a 50-foot, 12" dbh jack pine, and three fledglings left the nest on about 20 July. They used the 1959 nest again in 1961, rearing three young which left the nest in late June. The nests were all essentially as described by Bent (op. cit.:126-127), except that they have all been situated in jack pine, in preference to hardwoods.

In 1960, Goshawks were present on the Forest, but they did not utilize the nesting area occupied the preceding four years, and their activity center could not be located.

This nesting area is now classed as a jack-pine, pole-stage, heavily stocked forest type by forest management standards, consisting of a fairly dense mixed stand of 50-60-foot, 64-year-old jack and red pines (*Pinus resinosa*) (resembling in general character the situation studied by Schnell (1958) in California's Sierra Nevada). A few quaking aspen (*Populus tremuloides*) and paper birch (*Betula papyrifera*) are scattered among the pines.

There are several small openings in the forest canopy 100 to 200 feet west of the nesting area, partly created by fallen aspen and pines. Several of these trees are broken, the trunks forming horizontal perches 2 to 6 feet above the ground (Fig. 2A). These perches have been favored by Goshawks for dismembering and devouring their prey, and it has been under these sites



FIG. 2. (A) Fallen tree regularly used as a "plucking" or feeding perch by Goshawks in the spring of 1961; (B) Typical remains of six Ruffed Grouse after Goshawks have finished feeding; (C) Drumming Log 19G2, as it appeared during the height of the drumming season in April 1959; (D) DL 19G2, after the surrounding vegetation has leafed out, in late May 1959. This log has been used by a different bird each spring since 1957. The drumming site is about one foot to the right of the target stake—as indicated by the pointer.

that we have found most of the prey remains (Fig. 2B). This area of about one acre in extent will be called the "feeding area" in the remainder of this paper (as distinguished from the "foraging range," the area over which the Goshawks hunt in search of prey).

Although Schnell (*op. cit.*:379) uses the term "plucking perch" to describe the horizontal logs used by Goshawks in their nesting area in California we cannot use this term on this Forest, since plucking of grouse (and most other

prey) was invariably done afield, probably at or near the site of capture, and the perches in the feeding area were used for dismembering and devouring plucked prey.

METHOD OF OBTAINING DATA

Records of predator losses on the Cloquet Forest have been obtained in large part by forest management students from the St. Paul campus of the University of Minnesota, who spend a spring term on this Forest. Each team of two students is assigned part of the Forest to be forest-typed and inventoried, and it is during these activities that most of the predator-kill records are obtained. Since all upland parts of the Forest have been worked in approximately the same manner, by about the same number of students each of the years covered by this study, we believe that sampling has been fairly consistent. All kills reported by students have been examined by Wildlife Project personnel.

Determination of species responsible for predation is a problem. There has been little doubt as to the species involved in the 73 grouse remains found in the Goshawk feeding area, or among the grouse whose bands were found in bobcat scats, owl or Goshawk pellets, or where tracks were evident in the snow or dust. Among the remaining kills the presence of hawk or owl "whites" and plucked remiges, was considered indicative of raptor kills, whereas sheared remiges suggested mammalian predation. Goshawks frequently leave the larger grouse bones uneaten, such as the sternum and legs, whereas the larger owls seldom leave any scraps of meat or bone.

Goshawk feeding habits made the examination of their pellets and nests virtually useless in this area (in contrast to Meng's (op. cit.) dependence upon these sources for his data). The stripping of feathers from carcasses before they are brought to the feeding area, and the stripping of meat from the larger bones mean that little evidence of grouse remains can be expected in pellets (cf. Glading, et al., 1943). We did examine pellets whenever encountered for grouse bands. Also, as Table 1 demonstrates, less than 15 per cent of known grouse kills occurred while Goshawk nestlings were being fed.

One problem complicating the evaluation of the extent of Goshawk predation upon Ruffed Grouse is the matter of separation of remains. There undoubtedly were instances in which the plucked feathers from a kill were located at one site and the sternum, legs, bands or back-tag from the same grouse was counted again when recovered at the Goshawk feeding area. However, the percentage (25 per cent) of known banded grouse in the recorded kill compares favorably with the percentage of grouse known to be banded in the general population, and it is hard to believe that this duplication is too extensive. In the fall and winter of 1956-57, 40 per cent of the

TABLE I
PERIOD OF KNOWN RUFFED GROUSE LOSSES TO GOSHAWKS

| Year | Spring | | | | Summer | | | | Fall | | | | Winter | | | | Un- known | To- tals |
|--------|--------|------|-----|---|--------|------|------|---|-------|------|------|---|--------|------|------|---|--------------|-------------|
| | Mar. | Apr. | May | ? | June | July | Aug. | ? | Sept. | Oct. | Nov. | ? | Dec. | Jan. | Feb. | ? | | |
| 1956 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 2 |
| 1957 | 0 | 2 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 8 |
| 1958 | 1 | 8 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 16* |
| 1959 | 0 | 14 | 4 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7† |
| 1960 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 4 |
| 1961 | 3 | 12 | 7 | 1 | 4 | - | - | - | - | - | - | - | - | 0 | 0 | 0 | 0 | 27 |
| Totals | 4 | 37 | 17 | 1 | 8 | 0 | 0 | 1 | 0 | 0 | 2 | 1 | 0 | 1 | 0 | 1 | 0 | 98 |

* These kills were made between August 1957 and 25 April 1958, three banded grouse included in this group were all alive as late as 10-19 October 1957—these were probably mostly spring, 1958, kills.

† These kills were made between 4 June 1958 and 10 April 1959—the one banded grouse included was believed to have survived the fall, 1958, drumming season, and to have been active in early April 1959.

192 grouse satisfactorily observed during field observations on the north-eastern two square miles of the Forest proved to be back-tagged and/or banded. This figure climbed to 56 per cent of the 86 satisfactory observations in the fall and winter of 1957-58. (These figures for 1957-58 are believed comparable to the banded-unbanded ratio of preyed-upon grouse, since the observations sampled about one-third of the Goshawk foraging area, and there were probably few banded grouse in the unsampled area.)

SPECIES PREYED UPON BY GOSHAWKS

Systematic recording of prey species taken by Goshawks on the Forest has not been maintained, and often predator (and sometimes prey) species are uncertain. However, in addition to Ruffed Grouse, we have definite records of Goshawks taking snowshoe hares (*Lepus americanus*), cottontails (*Sylvilagus floridanus*), red squirrels (*Tamiasciurus hudsonicus*), flying squirrels (*Glaucomys* sp.), an unidentified duck (Mallard?), Blue-winged Teal (*Anas discors*), Common Nighthawks (*Chordeiles minor*), Pileated Woodpeckers (*Dryocopus pileatus*), Yellow-shafted Flickers (*Colaptes auratus*), Blue Jays (*Cyanocitta cristata*), Eastern Meadowlarks (*Sturnella magna*), and Robins (*Turdus migratorius*).

In 1956, 1959, and 1961, a significant portion of the remains found under the active Goshawk nests represented Common Crows (*Corvus brachyrhynchos*), although crows are not known to nest on the Forest or within three-quarters of a mile of the Goshawk nesting area. In 1956 the remains of no less than 11 to 13 crows were recovered from under the two Goshawk nests, and in 1959 at least 9 crows were fed to the hawk nestlings in the north-

TABLE 2
AGENTS RESPONSIBLE FOR KNOWN RUFFED GROUSE LOSSES ON THE CLOQUET FOREST
RESEARCH CENTER, 1956-1961

| Responsible agent | Total losses | Numbers of banded grouse taken | |
|----------------------------|--------------|--------------------------------|-------------|
| | | Total | Drumming ♂♂ |
| Goshawk | 98 | 24 | 15 |
| Owls (mostly Horned) | 17 | 6 | 6 |
| Undetermined raptor | 19 | 5 | 1 |
| Fox | 10 | 7 | 2 |
| Bobcat | 3 | 1 | 0 |
| Undetermined mammal | 10 | 5 | 3 |
| Undetermined predator | 14 | 3 | 1 |
| Hunter kill* | 16 | 12 | 12 |
| Road kill | 15 | 5 | 2 |
| Miscellaneous and unknown† | 30 | 12 | 8 |
| Totals | 232 | 80 | 50 |

* Hunter kills on or immediately adjacent to the Forest only; 10 more grouse which dispersed off the Forest have been taken by hunters.

† Mostly birds killed by predators in traps, and various accidental losses.

central area. The structure of bones and parts of mandibles recovered from these sites indicated that most of the crows were either nestlings or fledglings recently out of the nest.

PREDATION UPON RUFFED GROUSE

It is exceedingly difficult to assess fully the influence of Goshawk depredations upon Ruffed Grouse populations. However, our present data indicate that Goshawk predation constitutes the most important single factor decimating Ruffed Grouse populations on the Cloquet Research Forest.

From the spring of 1956 through the spring of 1961, 501 Ruffed Grouse were banded on the Research Forest. Of the 80 recoveries from among these banded grouse (to the end of June 1961), 24 (30 per cent) of the kills can be attributed to Goshawk predation. This compares with 12 (15 per cent) taken on or adjacent to the Forest by hunters; 27 (34 per cent) taken by all other predators; and 17 (21 per cent) lost to miscellaneous or unknown causes (see Table 2).

Among 232 records of grouse kills (banded and unbanded) on 3,352 acres during the study period, at least 98 (42 per cent) were the result of Goshawk activity. This represents 58 per cent of the kills attributed to non-human predators.

Sixty-three per cent of the banded grouse known to have been taken by Goshawks were males active in drumming activity centers (cf. Gullion, et al., 1962a). However, Goshawk predation is by no means restricted

to the drumming males, although it appears to be somewhat heavier on this segment of the population. Ratio of identifiable remains (banded and unbanded) has been $141 \delta \delta : 100 \text{♀} \text{♀}$, which differs somewhat from the trapped bird ratio of $101 \delta \delta : 100 \text{♀} \text{♀}$ for this same period.

Of importance is the fact that recovered remains (from all decimating agents) have accounted for only about 24 per cent of the banded male Ruffed Grouse believed to have been lost from the Cloquet Forest population during the 1956–1960 period. Since male grouse normally spend the remainder of their life in a certain activity area once established in it, their disappearance and replacement by other males can generally be regarded as evidence that the missing birds are no longer extant (we have recorded at least one exception to this, however).

Using this information, plus other data, we have calculated that this one pair of Goshawks has killed approximately 190 grouse on this forest during 1956 to 1960. These figures are not exact, but are given merely to indicate the probable order of magnitude of this factor in the dynamics of this grouse population. Several assumptions have been made which may introduce an error of up to 20 per cent in the total figure. For example, there are an additional 19 records of grouse killed by unknown avian predators, and 14 more by totally unknown predators, some of which were probably Goshawk prey. Also, we do not know how many grouse have been taken into fox dens, leaving behind no trace of their fate.

Since Goshawks are seldom present on the Forest during the winter, most of this predation has occurred in the fall and spring, mostly during April and May (Table 1). This period is the drumming season for the male Ruffed Grouse, and is also the period during which cover is seasonally poorest. In 1959, for example, the ground was bare of snow shortly after the end of March, and the leaves of beaked hazel (*Corylus cornuta*) and bracken (*Pteridium aquilinum*), which provide the major cover for grouse in this Forest, did not become an effective canopy of cover until the last week in May (Fig. 2C & D). Also, during this early spring period there are only a few large prey species available to Goshawks, of which Ruffed Grouse are probably as readily available as any others. In May the arrival of migrant birds from the south provides a great diversity of prey species. This, coinciding with the development of vegetative cover, is reflected in the decided decrease in the numbers of grouse taken by Goshawks while feeding their nestlings.

AREA OF GOSHAWK INFLUENCE

Figure 3 shows the distribution of known Goshawk kills in the 1956–1961 period (and the location of unclassified raptor kills, some of which probably involved Goshawks). Among the 37 kills whose origin could be determined,

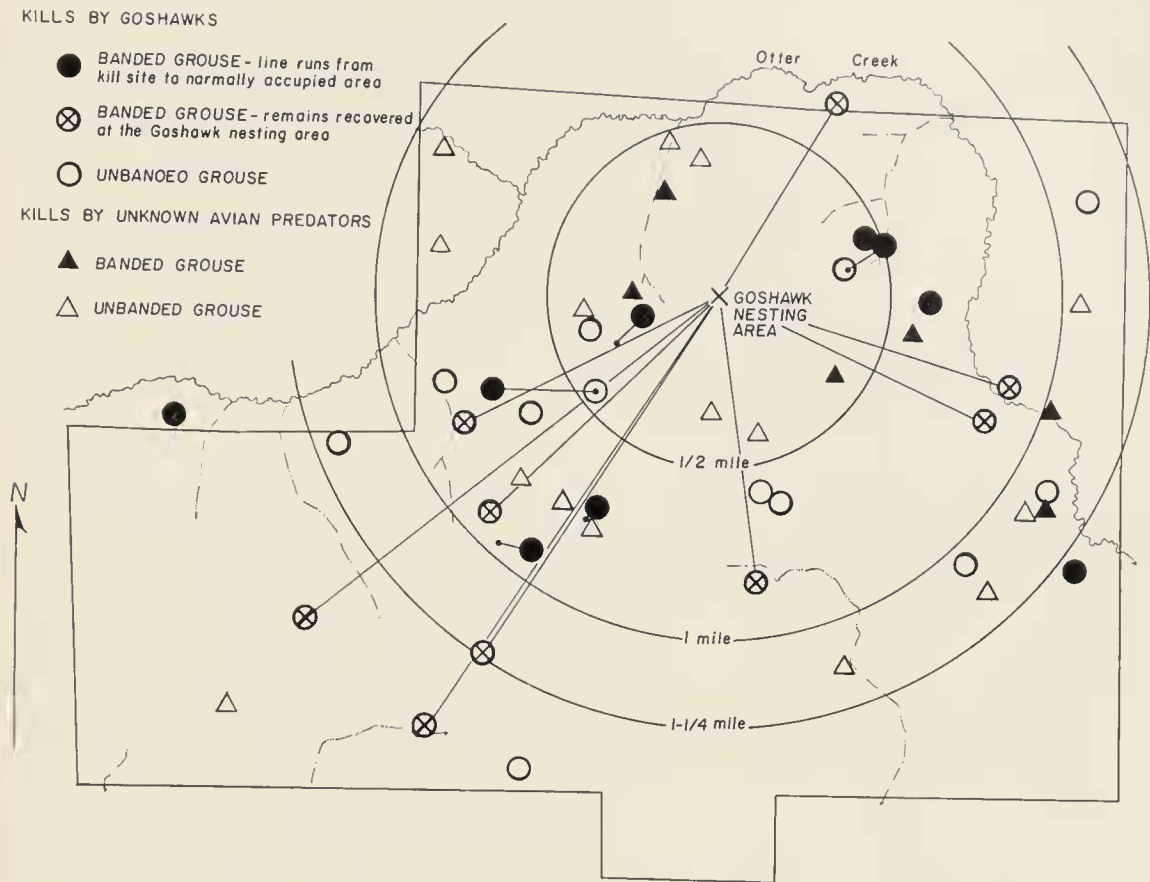


FIG. 3. The location of known Goshawk and unidentified avian predator kills of Ruffed Grouse on the Cloquet Forest Research Center, 1956-1961. Not shown are the remains of five banded grouse of unknown origin and 37 unbanded grouse recovered in the Goshawk nesting area.

all but five were made within a $1\frac{1}{4}$ -mile radius of the Goshawk feeding area, and 26 of the kills were within a 1 mile radius. The nine banded males brought into the feeding area from their drumming territories were probably killed at distances ranging from approximately 3,600 to 8,250 feet (a mean distance of 5,460 feet) from the Goshawk nest. These data indicate that the Goshawks foraged primarily in an area of about 3,200 acres (5 square miles).

Of interest is the scarcity of records of banded grouse taken within a $\frac{1}{2}$ -mile radius of the feeding area. We believe that this reflects the effectiveness of the Goshawk predation within this area, indicating that grouse entering this area seldom survive long enough to be trapped and banded. In fact, grouse populations within this "circle of suppression" have been so consistently low that there has been little reason to conduct trapping within this area. Trapping, including mirror-trapping for drumming males, has been done at 16 sites within this circle in the past three years, producing 48 grouse (0.96 bird/acre), while within the next $\frac{1}{4}$ -mile-wide concentric ring trapping has been carried on at 39 sites, resulting in the banding of 146 grouse (2.3 birds/acre).

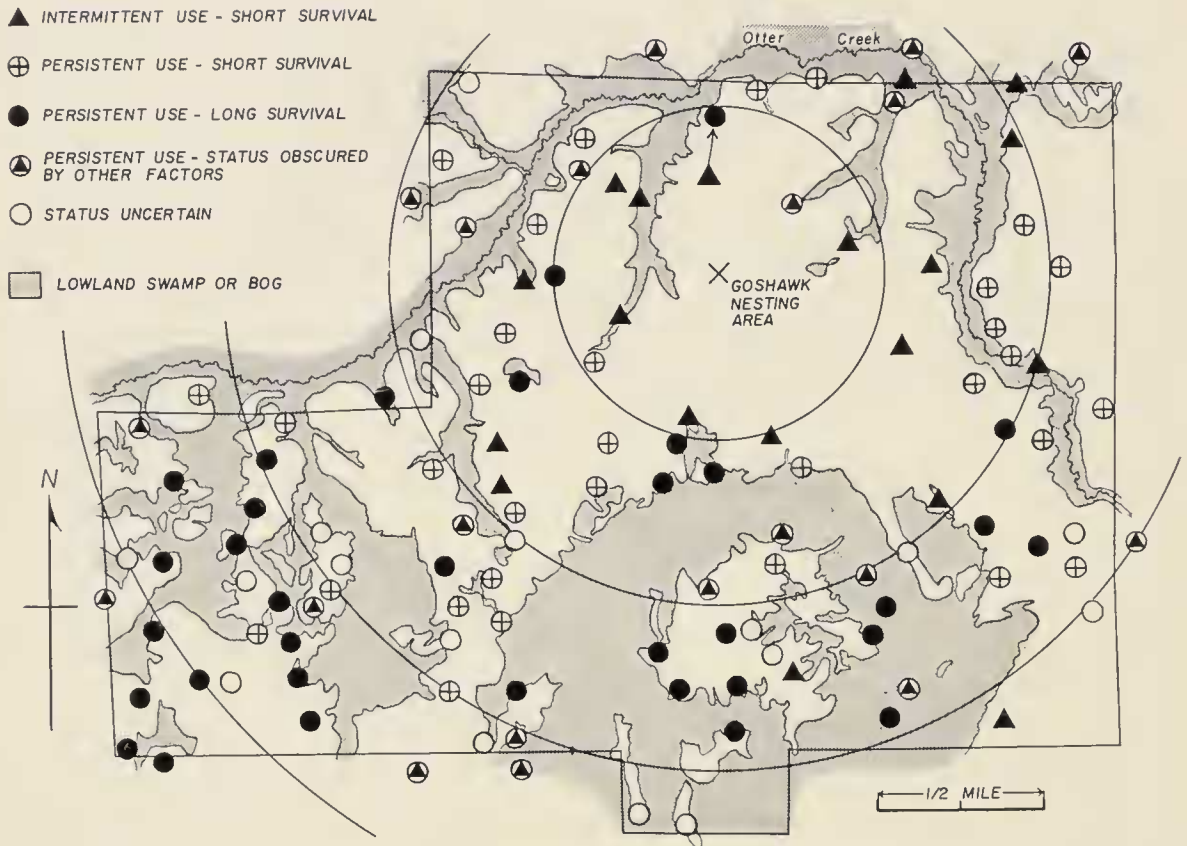


FIG. 4. Distribution and use of grouse drumming activity centers, and normal survival of male grouse occupying each activity center, in relation to distance from the Goshawk nesting area, Cloquet Forest Research Center, 1956-1960. Short survival is less than one full year of activity center occupancy; long survival means the drumming male survived to use his activity center at least a second spring. Intermittent use—activity center not occupied every spring; persistent use—activity center occupied every spring.

The efficiency of predation within this 1-mile-diameter "circle of suppression" is partially reflected by the scarcity of active drumming male grouse within this area. As shown in Fig. 4, this "circle" is the only extensive upland area on the Cloquet Forest which is nearly devoid of established drumming activity centers. In 1959, the 2,200 acres of upland on the Forest averaged one drumming male grouse per 34 acres, or one drumming male per 29 acres if the area of this "circle" is subtracted from the total. By contrast, in 1959, within the 448 acres of upland included in the "circle of suppression" there were only four actively and persistently drumming male grouse (all of these being located more than $\frac{1}{4}$ mile from the Goshawk feeding area, with a mean distance of 2,180 feet from this area), or one drumming activity center per 112 acres.

Table 3 presents another evaluation of the effectiveness of predation in relation to the distance drumming activity centers are located from the Goshawk feeding area (see also Fig. 4). In only one drumming activity center within the "circle of suppression" has a male grouse survived to drum

TABLE 3

SECURITY STATUS OF DRUMMING ACTIVITY CENTERS IN RELATION TO THEIR DISTANCE FROM GOSHAWK FEEDING AREA—CLOQUET FOREST RESEARCH CENTER

| Distance from Goshawk feeding area (in miles) | Intermittent use—short survival | Persistent use—short survival | Persistent use —2+ years survival | Persistent use—status obscured by other factors | Status uncer- tain—short history | Totals |
|---|---------------------------------------|-------------------------------------|---|--|--|--------|
| < 1/2 | 5 | 1 | 1 | 1 | 0 | 8 |
| 1/2 to 3/4 | 4 | 8 | 5 | 3 | 0 | 20 |
| 3/4 to 1 | 6 | 9 | 1 | 6 | 2 | 24 |
| 1 to 1 1/4 | 2 | 6 | 7 | 1 | 4 | 20 |
| 1 1/4 to 1 1/2 | 0 | 4 | 8 | 1 | 4 | 17 |
| 1 1/2 to 1 3/4 | 1 | 2 | 4 | 5 | 3 | 15 |
| 1 3/4 to 2 | 0 | 1 | 5 | 1 | 2 | 9 |
| 2+ | 0 | 0 | 4 | 1 | 0 | 5 |

a second spring—this bird survived from the spring of 1957 to the winter of 1959–60. In fact, only one activity center (19G2) within this circle has been used perennially during the past 5 years, but by a different male grouse each spring (Fig. 2C–D).

As the radii from the feeding area lengthen, more drumming activity centers are persistently occupied. However, it is not until a radius of 1 1/4 miles is exceeded that we reach an area where the majority of the drumming males survive to drum a second year.

We do have some evidence which suggests the efficiency of predation within this “circle of suppression,” and how rapidly the Goshawks remove any male grouse bold enough to drum within this area. During the spring of 1959, 11 forestry students were hired to be out early every morning throughout April, searching for new drumming logs, and recording activity on known logs. The efforts of these men, plus the two men currently working on the grouse research project (John J. Kupa and the junior author), resulted in intensive coverage of the entire Forest, which we believe succeeded in locating nearly every drumming grouse on or within 1/8 mile of the Research Forest (78 of the 82 male grouse located were trapped or identified). One of the results of this intensive coverage was the repeated criss-crossing of the area within 1/2 mile of the Goshawk feeding area by three different men.

One morning two grouse were heard drumming within about 800 feet of one another (at a point about 2,000 feet ENE of the Goshawk area). One bird was located at about 7 AM (CST), but by noon of that same day it had been taken by a Goshawk. The other bird's log was not located, and since

another grouse immediately replaced the killed bird, we believe that the replacement was the second grouse.

Another drumming grouse was heard on two consecutive mornings in an area about 1,500 feet to the northwest of the Goshawk feeding area. This bird was not heard again, nor was his drumming site ever located.

At least two factors appear to contribute considerably toward the presence of this ½-mile "circle of suppression," namely the logistics involved in the activities of the Goshawk and the vegetation present in the area.

The first factor is apparent. The foraging trips from the focal point of Goshawk activity (nest and feeding area) would provide coverage in decreasing intensity outward from this point. Schnell (op. cit.:381) notes female Goshawks dropping directly off the nest to take nearby prey. Thus the area immediately adjacent to the nest would be subjected to the greatest degree of surveillance by the Goshawk.

The second factor concerns the cover type involved. Habitat on this forest most commonly used by drumming Ruffed Grouse (cf. Eng, op. cit.) consists of an upland type but often in the vicinity of an upland-lowland edge. This "circle" embraces a portion of the largest segment of continuous upland area on the forest (Fig. 4) and includes one of the more uniform stands of mature jack pine. Thus with the exception of the edge along the lowland in the west half of the "circle," this area cannot clearly be called high security Ruffed Grouse drumming habitat.

Forty-one drumming logs recorded from this area by Ralph T. King (MS) during the four seasons from 1931 to 1934, and the 22 drumming sites recorded by William H. Marshall (MS) between 1946 and 1953, possibly contradict the idea that this is a lower security area. Our records have shown but nine sites in this area during the six seasons from 1956 through 1961. However, the spring grouse densities reported by Marshall (1954) for the periods 1931-34 and 1946-53 included spring populations which were approximately three to five times the size of comparable populations observed by us during the 1956-61 period. Evidence is present (cf. Eng, op. cit.) to suggest that during population highs, additional drumming sites would undoubtedly be established in less secure areas, probably in adequate numbers to be observed even in the face of rapid removal due to this insecurity.

DISCUSSION AND CONCLUSIONS

Combining the data on the foraging radius of these Goshawks, plus that on survival of males occupying specific drumming activity centers, it seems apparent that this predation appreciably lowers the security of Ruffed Grouse living within the hawks' foraging range (an area of about 5 square miles).

There is possibly a significant suppression of the grouse population within a $\frac{1}{2}$ -mile radius of the hawks' feeding area. The data indicate that the Goshawks' foraging efforts regularly extended out to a radius of at least $1\frac{1}{4}$ miles from the nest, but with decreasing effectiveness. The area involved in the "circle of suppression" is approximately 16 per cent of that in the entire foraging area. We cannot accurately measure how much of this lower population within the $\frac{1}{2}$ -mile "circle of suppression" is due to less satisfactory habitat and how much is due to the effects of predation by a single species.

The predation by these Goshawks within their foraging range appears significant as a mortality factor in this grouse population. Over the past four seasons (1957-1960), the Goshawk toll is calculated to be at least 9.7 grouse per square mile per year, as compared to spring breeding populations of 21 to 28 grouse per square mile. Our first year fall-to-spring grouse population decline of each cohort exceeds 50 per cent, almost wholly due to natural mortality. Among the natural decimating factors, Goshawks have taken at least 58 per cent of known losses. Therefore, we can say with some certainty that Goshawk predation has been responsible for probably more than 50 per cent of the overwinter losses from each age class of Ruffed Grouse on the Cloquet Forest during the past several years, or a take equalling more than 25 per cent of each year's fall juvenile grouse population.

We cannot say whether or not this predation has seriously affected grouse population trends on this area. Our records show the population trends to be comparable to those in adjacent areas. On the other hand, a small area of depression could readily and fairly constantly be restocked by birds from surrounding areas, without a noticeable depression in numbers in these adjacent areas.

Although a reservoir of "non-drumming" males appears to exist in most Ruffed Grouse populations, this reservoir seems to be smaller within the area influenced by Goshawks, and replacement on logs is less certain (Fig. 3). In the area most affected by Goshawks there has been no replacement of lost drummers by adult males from the nondrumming reservoir, something that occurs occasionally in other areas. The regularity with which drumming grouse are taken from certain, specific logs, suggests that some sites may be subjected to more than random hunting.

One factor of probable importance in the effectiveness of Goshawk predation upon Ruffed Grouse on the Cloquet Forest has been the back-tagging of grouse to aid in field identification of individual birds, similar to the technique described by Blank and Ash (1956). Most of the back-tagging was done between the fall of 1956 and the spring of 1958, which coincides with the period of heaviest recorded grouse losses to Goshawks (Table 1). Other data on the survival of back-tagged grouse have shown it to be consid-

erably less than for birds that are only leg banded (cf. Gullion, et al., 1962*b*). At least 17 of the 24 banded grouse taken by Goshawks were known to be back-tagged when taken, or shortly before.

The threat Goshawks pose to an area-wide Ruffed Grouse population is probably insignificant. These accipiters are comparatively rare and the scarcity of nesting records for Minnesota (cf. Roberts, loc. cit.) indicates that there are probably very few grouse populations subjected to this intensity of predation in this state. Only in 1956 did more than one pair of Goshawks nest on this Forest.

The seasonal heavy loss of the more vulnerable drumming males cannot be regarded a hazard to production since, even during the comparatively low grouse population encountered during this study, there was evidence of an ample reservoir of nondrumming replacement males in surrounding areas.

In conclusion, this study indicates that Goshawk predation in this area does not conflict with the management of this game bird for two reasons. Firstly, this refuge does not contribute significantly to the harvestable populations of grouse in the adjacent hunted area (cf. Gullion and Marshall, 1960). The lack of hunter competition for grouse on the refuge may even enhance the Goshawks' existence. Secondly, even in areas subjected to hunting pressure, the period of greatest predation on grouse by Goshawks occurs in the spring, well after the hunting season, and is directed primarily toward males. In the final analysis it seems probable that a large portion of the Ruffed Grouse lost to Goshawk predation in this general area represents surplus birds, many of which were available to, but not taken by hunters during the hunting season.

We do not agree with Meng's suggested conclusion (op. cit.:173) that Goshawks do not affect grouse abundance within local areas, and in fact "may even be instrumental in increasing the numbers of grouse by removing numerous crows." Whether or not grouse abundance influences the locale of Goshawk nesting cannot be answered, but it is certain on this Forest that Ruffed Grouse constitute a large proportion of the food consumed by Goshawks during the prenesting and incubation periods.

We do agree that the Goshawk should be afforded legal protection, not because it is a "harmless" predator, but because it is a noble, interesting and uncommon part of our nation's wildlife heritage.

Our rather limited observations on Goshawk nesting behavior generally agree with those reported by Zirrer (1947) and Schnell (op. cit.). Here the male appears to be in the nesting area more often than Schnell reported. On several occasions after nestlings were well grown the male was the only bird in the area when the nest was visited. He never attacked an intruder but always made a loud vocal protest while flying back and forth above the forest

canopy. Frequently the female would return to the nest site within a few minutes, perhaps in response to the male's calling, and she would aggressively attack a single person in the vicinity of the nest, but only protested vocally if there were more than one person present.

SUMMARY

Ruffed Grouse investigations on the Cloquet Forest Research Center, Minnesota, from 1956 through 1961 have permitted observations on the predatory activities of Goshawks on this grouse. Intensive Ruffed Grouse population and banding studies plus continued occupancy of a Goshawk nesting and feeding site have provided the basis for these observations.

Goshawk predation was the most important single mortality factor for full-grown Ruffed Grouse in this un hunted population, accounting for 30 per cent of the known losses of banded grouse.

These losses were heaviest during the spring period when cover was considered to be lowest in quality and quantity. Male grouse, and more specifically males active in drumming activity centers, made up the largest segment of these losses.

Thirty-two of 37 grouse kills of known origin were made within $1\frac{1}{4}$ miles of the Goshawk feeding site. Twenty-six of these kills were within a one-mile radius. Nine banded males brought in from their drumming activity centers were probably killed at a mean distance of about 5,460 feet from the Goshawk nest site. Thus the Goshawk predatory efforts were extended to an area of about 5 square miles.

The data obtained suggested the presence of a "circle of suppression" with a $\frac{1}{2}$ -mile radius from the Goshawk nest and feeding area. Evidence is presented substantiating the existence of this area. The presence of this area is believed to be due in part to the increased coverage given it by the foraging Goshawks and to the quality of grouse habitat in the "circle."

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